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(54) Electrical arc fault detector

(57) An electrical arc detector, capable of detecting without electrical connection, and providing warning of an electrical arc fault condition in an electrical appliance eg. an electric blanket, has an oscillatory magnetic sensor (S) located close to the mains supply lead of the appliance so that, upon the occurrence of an arc fault condition, an oscillatory magnetic field around the mains lead is detected. The signal generated by the sensor (S) triggers a latching circuit (TR1, TR2) with a positive feedback loop (R4), which actuates a transistor (TR3) connected to audible and visual alarm devices and or a cut-out. A test switch (T) is provided.

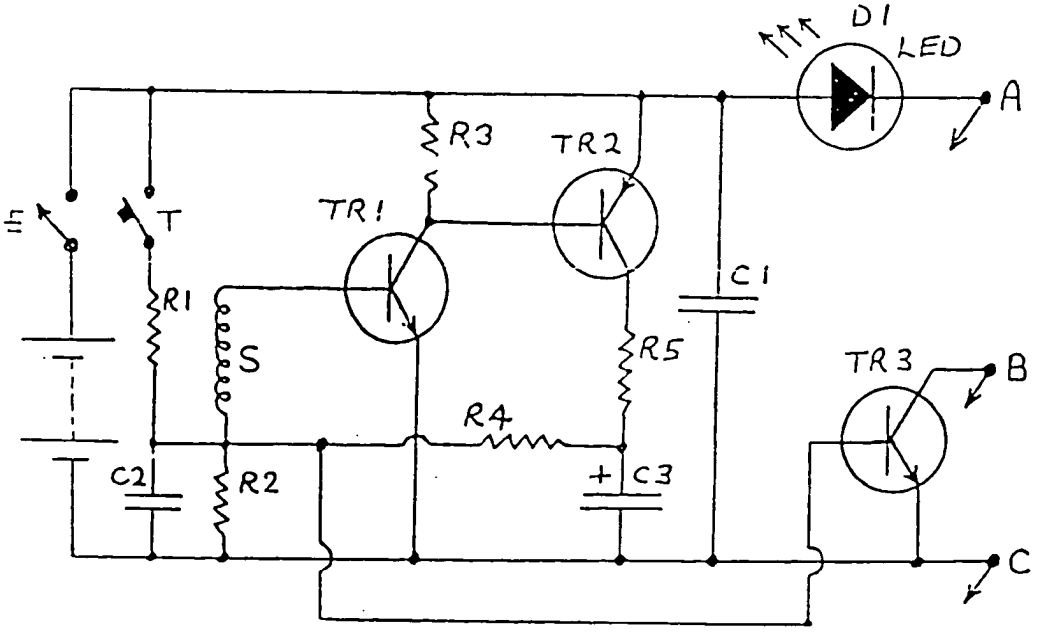

Fig 3.

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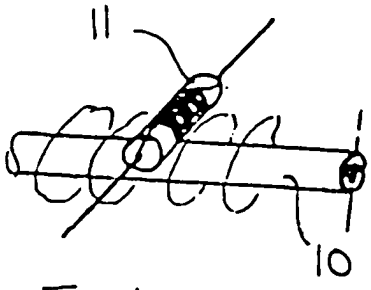

Fig 1a

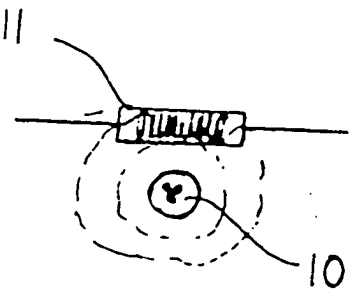

Fig 1b.

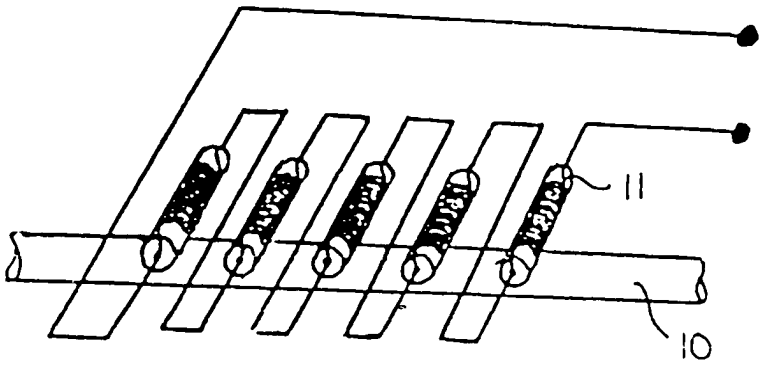

Fig 2.

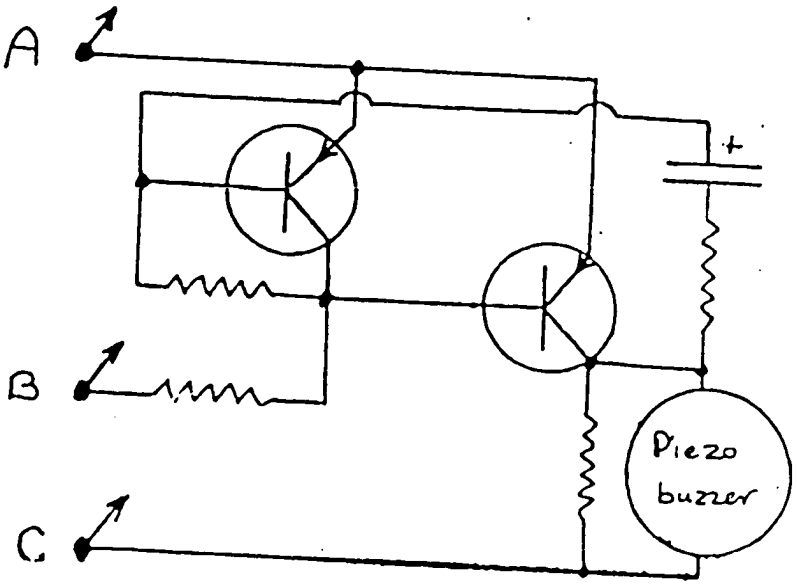

Fig 4.

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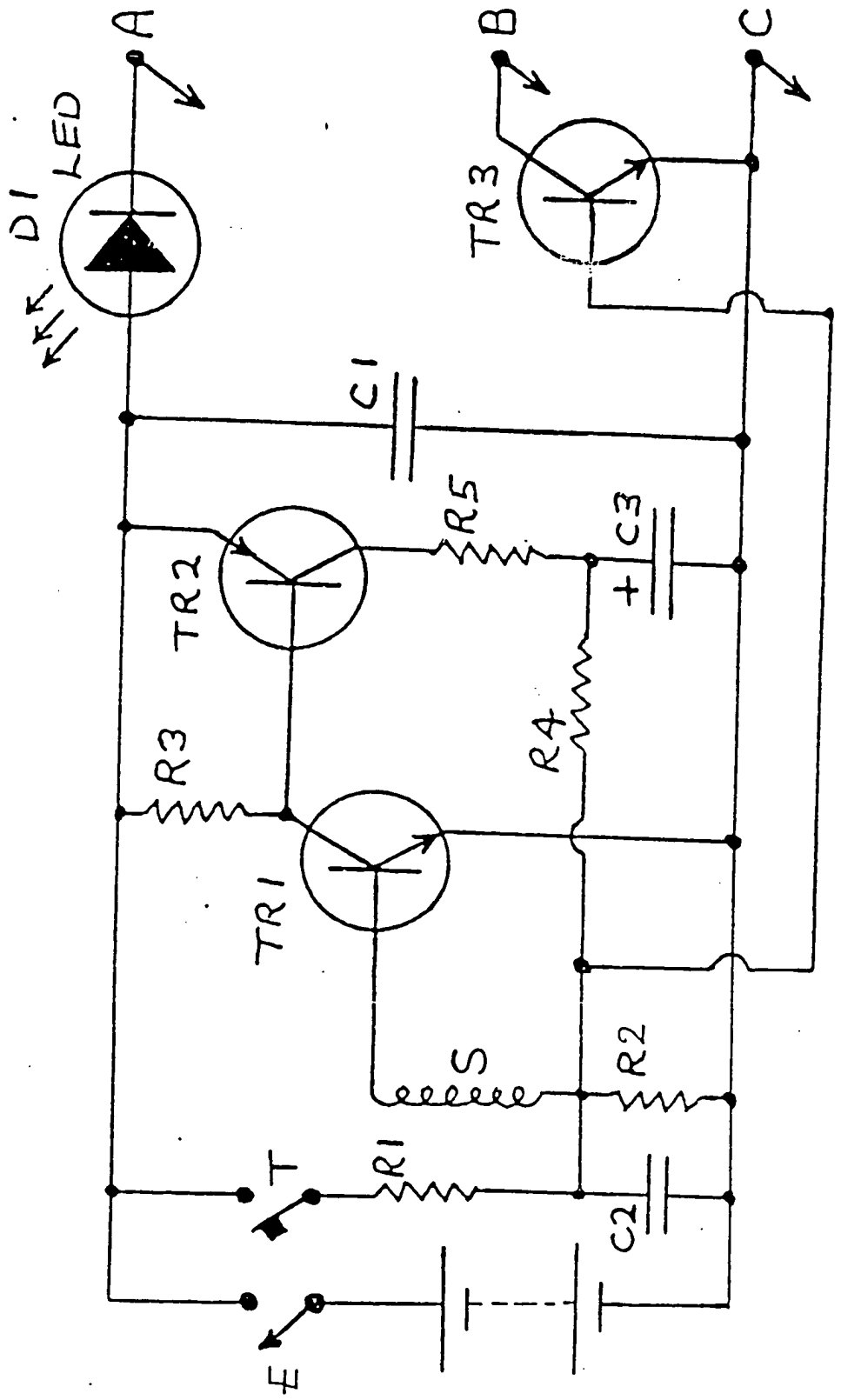

fig 3.

SPECIFICATION

Electrical arc fault detector

The present invention relates to an electrical arc fault detector which is capable of detecting, without electrical connection, and providing warning of, an electrical arc fault condition that can develop in electrical applicances. The present invention is particularly suitable for use with domestic appliances, such as an electrically heated blanket, where an electrical arc hazard may eventually cause a fire or consuming the blanket and any surrounding combustible material. Obviously, such appliances, if faulty or damaged can be of considerable danger to both life and property.

The electrical arc fault condition can occur in an electrical circuit where a current conducting wire is severed and the loose ends are in close intermittent contact, with the arc then developing between the severed ends, especially when the circuit is significantly inductive and the level of current is sufficient to sustain the arc. Such conditions have been observed in AC mains voltage operated electric blankets, where an arc at the severed strands within an insulated multi-strand conductor inside the blanket has eventually burnt through the insulating material and ignited the blanket and the surrounding bed linen.

It is the object of the present invention to provide a detection device capable of detecting, without electrical connection, an electrical arc fault condition in an electrical circuit and providing an output when said condition is detected.

According to the present invention there is provided a detection device, capable of detecting, without electrical connection, an electrical arc fault condition in an electrical circuit, comprising an oscillatory field magnetic sensor locatable, in use, in close proximity to a conductor of said electrical circuit, the output of said sensor being supplied to an amplification and latching circuit, the output of which is connectable to actuate a visual or audible warning device and or a safety cut-out device.

The arc detector device is preferably a battery-operated device, which may be simply attached to the mains supply lead of the electrical applicance, e.g. clipped on to or around the mains lead at any convenient position. Since no electrical connection is required to the appliance to be protected, the device can be readily attached and removed when the applicance or blanket is not in use. The arc detector circuit preferably utilises transistors in a zero-biased, zero-current mode to enable operation of the detector circuitry for a period equal to the 'shelf-life' of the battery supply, when switched on in the armed state, and a test switch or button is preferably provided which, when operated, tests for correct operation of the alarm circuit, and which may also serve as a battery level check.

The audio or visual alarm may be of any conventional type including light emitting diodes or incadescent bulbs and or mini DC or piezo buzzers or solid state tone generators connected to miniature loudspeakers. Alternatively, provision could be made or included for a cut-out device for the mains supply to switch off the current, when an electrical arc is detected.

The present invention will now be described further with reference to the accompanying drawings in which: -

Figures 1a and *1b* illustrate an oscillatory magnetic field sensor;

Figure 2 illustrates an oscillatory magnetic field sensor array;

Figure 3 illustrates an arc detector circuit; and

Figure 4 illustrates an audible alarm circuit.

Referring firstly to Figures 1a and 1b, the detection principle for the present invention is illustrated, in which a mains lead 10 is shown with a sensor 11 mounted proximate thereto, the sensor 11 suitably being an iron dust core choke. When a continuous arc fault condition arises, owing to severing of a current conducting wire of the appliance whilst the loose ends are held in close intermittent contact, an electrical arc thereby produced would be comprised of an oscillatory current flow which generates high frequency oscillatory magnetic fields surrounding the mains supply lead. The sensor 11, placed in close proximity to the mains lead 10 detects the presence of such magnetic fields and a current is induced in the iron dust core choke when orientated as shown in Figure 1a. In view of the fact that the magnitude of such fields and hence the induced current in the choke are relatively small, the sensitivity of the device can be increased by connecting a number of chokes together in series as shown in Figure 2 to provide a phased array. The signal produced in the oscillatory magnetic field sensor 11 reproduces the wideband signal components of the arc caused by the severing of the leads.

Referring now to Figure 3, the arc detector circuit of the present invention is shown, in which the oscillatory magnetic field sensor is designated as S and the output of such is applied to the base of transistor TR1 and to one end of by-pass capacitor C2. In a 50 hertz AC circuit; the arc current detected when a fault arises exhibits a pulse train effect with a period of 10 milliseconds in which the wideband oscillatory currents peak and rapidly decay. The positive-going signal component in the 10 millisecond interval pulse train bursts applied to the base of transistor TR1 and will cause corresponding conduction through TR1 when the base emitter input levels approach or exceed the 0.6 V "turn-on" levels required for silicon transistors. The output of transistor TR1 is supplied to the base of transistor TR2, whose collector feeds an RC time constant circuit formed by resistor R5 and capacitor C3 so that the original busts of wideband signals applied to the base of transistor TR1 at 10 millisecond intervals now appear as "ramping" step increases in the DC voltage across capacitor C3. This positive DC voltage is fed back to the base of transistor TR1 via the resistive divider R4, R2 which when set to a given ratio, e.g. 10: 1, provides forward bias to transistor TR1 thus increasing the gain of transistor TR1 and hence the sensitivity of the arc detector to the presence of oscillatory magnetic fields. With a continuous 10 millisecond interval "arc" pulse trains applied to the base of transistor TR1, the detector circuit rapidly traverses the increased sensitivity state to a point where "latch-up"

occurs. When the voltage across resistor R2 rises to a point where transistor TR1 is driven into full conduction, taking transistor TR2 also into full conduction, a stable "latch-up" state is achieved via the resistors R4 and R2 positive feedback path. When a "latch-up" state occurs, a sample of the "latch-up" bias on transistor TR1 is used to forward bias transistor TR3 and hence initiate a conventional piezo-buzzer audible pulsed alarm tone generator (see Figure 4) and a visual alarm is produced at light emitting diode D1.

The time interval from detection of the first wideband arc pulse to activation of the audible alarm, given a continuous train of arc pulses can be set by the ratio of resistors R4 and R2. Using a 10: 1 ratio, the arc detector gives audible warning after approximately ten, 10 millisecond pulses, i.e. approximately 100 milliseconds after detection of the first arc pulse.

The on-off switch E, while serving to switch on and "arm" the detector, is also used to "unlatch" or reset the alarm by switching off and then on again which allows the "latch-up" voltage across capacitor C3 to discharge through resistors R4 and R2 during the "off" state to a level where transistor TR1 conduction is not sustained. With on-off switch E 'on' and battery supply applied to the arc detector circuitry, no current is drawn from the batteries when the circuit is in the "armed" and "unlatched" state. This is achieved by zero forward bias operation of the transistor circuitry, which allows the arc detector to operate continuously in the "armed" state for the "shelf-life" of the batteries.

A further switch is provided for the detector circuit, namely the test switch T which, when operated, provides a controlled level of forward bias to transistor TR1 via the resistor divider R1, R2 and the chokes of the oscillatory magnetic field sensor S in order to generate a "latch-up" alarm activated state to test the correct operation of the circuit. Further, selection of the value of resistor R1 will determine the minimum battery voltage level below which a "latch-up" state will not be achieved, thus providing a check of satisfactory battery voltage level.

As will be appreciated, a variety of different types of alarm systems could be activated by the device of the present invention and although not particularly convenient for use with the device as currently envisaged, i.e. as a low cost safety device for attachment to existing appliances, such circuitry could alternatively be built-in to a control device for the appliance and could be connected to means for triggering a safety cut-off of the mains supply current as well as annunciating an alarm.

CLAIMS

1. A detection device, capable of detecting, without electrical connection, an electrical fault condition in an electrical circuit, comprising an oscillatory magnetic field sensor locatable in use proximate to a conductor of an applicance to be protected, the output of said sensor being connected to an amplification and latching circuit which, when a fault condition is detected, provides an output for actuating a visual or audible alarm and or a safety cut-out device.

2. A detector device as claimed in claim 1 in which the oscillatory magnetic field sensor is an iron dust core choke.

3. A detection device as claimed in claim 1 in which the oscillatory magnetic field sensor comprises a plurality of iron dust core chokes connected in series to provide a phased array.

4. A detection device as claimed in any preceding claim in which the amplification and latching circuit utilises a pair of transistors connected in a zero-biased, zero-current mode so that the circuit can remain in the "armed" state for the "snelf-life" of a battery supply therefor.

5. A detection circuit as claimed in any preceding claim wherein the output of the detector circuit is supplied to a visual and or audible alarm, device and or to a safety cut-off device for the supply current to the appliance to be protected.

6. A detector device as claimed in claim 1 in which the delay time from detection of a first arc pulse to activation of the alarm is adjustable.

7. A detector device as claimed in any preceding claim in which a test switch is provided which both enables a test of proper operation of the detection circuit and battery voltage level.

8. A detector device substantially as hereinbefore described with reference to the accompanying drawings.

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